1434

PHYTOTOXICOLOGY SECTION INVESTIGATION IN THE VICINITY OF WELLAND CHEMICAL, SARNIA ON AUGUST 23, 1989

FEBRUARY 1991

Ontario
Environment
Environnement

ISBN 0-7729-7892-1

PHYTOTOXICOLOGY SECTION INVESTIGATION IN THE VICINITY OF WELLAND CHEMICAL, SARNIA ON AUGUST 23, 1989

Report prepared by:

Phytotoxicology Section
Air Resources Branch
Ontario Ministry of the Environment

FEBRUARY 1991

RECYCLABLE

Cette publication technique
n'est disponible qu'en anglais

90-2231-015
PIBS 1434

1 Background

Welland Chemical, Scott Road, Sarnia is a manufacturer of anhydrous aluminum chloride. The product is manufactured by passing gaseous chlorine through molten aluminum and precipitating out the resulting product. During the removal of the product from the precipitators and in the subsequent handling and packaging there are fugitive emissions of the product. The product reacts with the moisture in the air to produce hydrochloric acid and aluminum oxide. Complaints of damage to vegetation in the immediate vicinity of the company have been observed since 1970.

The Phytotoxicology Section, Ministry of Environment has carried out assessment surveys around Welland Chemical Ltd. since 1970 (1). Annual surveys were carried out continuously from 1978 to 1987 (2,3,4,5,6,7,8). In all of the investigations to date there has been documented injury to vegetation in the vicinity of Welland Chemical. This injury has been attributed to emissions from the company. The injury, which usually develops in late July, is typical of chloride injury. Chemical analysis has revealed significantly elevated levels of aluminum and chlorine in the vegetation around Welland Chemical.

On August 23, 1989 Mr. R.D. Jones of the Phytotoxicology Section conducted a Phytotoxicology investigation in the vicinity of Welland Chemical. This is a report of the results of that investigation.

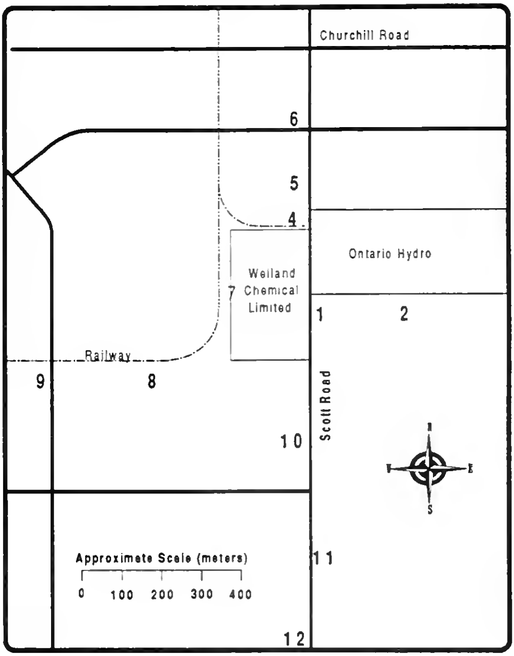
2 Methods

Duplicate bur oak (*Quercus macrocarpa*) foliage samples were collected at eleven stations within 750 meters of Welland Chemical. The sampling stations were the same as those that have been sampled annually since 1978 (see Figure 1). The samples were collected using standard Phytotoxicology sampling techniques (3).

All samples were delivered to the Phytotoxicology Section sample processing laboratory in Toronto where they were dried and ground before being submitted to the Inorganic Trace Contaminants Section, Laboratory Services Branch for chemical analysis. The samples were analysed for aluminum, cadmium, chlorine, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, sodium, strontium, vanadium and zinc.

At each collection site, in addition to sampling for chemical analysis, numerous indigenous plant species were examined for air pollution injury. These species included: bur oak, basswood, hawthorn, elm and white ash.

Figure 1: Map of the Vicinity of Welland Chemical Limited Showing the Location of 11 Vegetation Collection and Observation Sites, August 23, 1989.



3 Results

Trace to moderate injury was observed on basswood, oak, hawthorn, sumac and elm at station one. This injury was greatest at the edge of the road and dropped off rapidly east of the road. There was trace injury on oak at station four and trace to light injury on oak and basswood at station seven. All of the observed injury was typical chloride-type injury. There was no injury at any of the other sampling stations. The injury was similar to that observed in 1987.

The results for chloride analysis for 1982 to 1987 and 1989 are given in Table 1. The results for aluminum, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, sodium, strontium, vanadium and zinc analysis for 1989 are given in Tables 2 and 3. The results are expressed as either % or µg/g dry weight and are the mean of the duplicate samples collected at each site. All results were spatially evaluated using a mapping program called Surfer ver. 3.00 (Golden Software, Inc.) to determine if there was any pattern of declining levels with distance from the company. The distribution patterns for chloride, aluminum, sodium and molybdenum are given in Figures 2,3,4 and 5.

Table 1: Results of Analysis for Chlorine in Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia (% dry weight).

Sampling Site	1982	1983	1984	1985	1986	1987	1989
1	**1.18**	**0.33**	**0.38**	**0.31**	**0.61**	**0.36**	**0.39**
2	0.11	0.08	0.08	0.10	0.13	0.07	0.06
4	**0.42**	**0.39**	**0.23**	**0.37**	**0.34**	**0.53**	**0.22**
5	**0.36**	**0.32**	**0.18**	**0.23**	**0.24**	**0.28**	**0.18**
6	0.09	0.10	0.11	0.12	0.15	**0.17**	0.04
7	**0.82**	**0.49**	**0.23**	**0.34**	**0.25**	**0.52**	**0.32**
8	0.06	0.05	0.07	0.04	0.06	0.08	0.05
9	0.07	0.02	0.05	0.05	0.05	0.04	0.01
10	**0.60**	**0.27**	**0.27**	**0.43**	**0.25**	**0.30**	**0.19**
11	**0.31**	**0.19**	**0.20**	**0.26**	**0.19**	0.14	**0.18**
12	**0.24**	0.13	0.13	0.09	0.12	0.11	**0.17**
Mean of Sites 1,4,7&10	0.76	0.37	0.28	0.36	0.36	0.43	0.28
Rural ULN	0.15	0.15	0.15	0.15	0.15	0.15	0.15

Table 2: Results of Analysis for Aluminum, Cadmium, Chromium, Cobalt, Copper, Iron and Lead in Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia 1989 (expressed as µg/g dry weight).

Sampling Site	Aluminum	Cadmium	Chromium	Cobalt	Copper	Iron	Lead
1	120	<0.1	0.7	0.3	5.2	114	1.1
2	37	<0.1	0.5	0.4	4.6	80	<0.5
4	65	<0.1	0.6	<0.2	6.2	110	0.9
5	58	<0.1	0.5	<0.2	5.7	98	1.0
6	25	<0.1	<0.5	<0.2	5.6	76	0.7
7	99	<0.1	0.8	0.3	6.2	195	0.8
8	31	<0.1	0.5	<0.2	6.3	120	0.6
9	30	<0.1	0.6	0.3	5.8	99	<0.5
10	170	<0.1	0.7	<0.2	5.0	101	0.8
11	105	<0.1	0.8	<0.2	5.2	110	1.3
12	54	<0.1	0.8	0.2	4.9	90	0.5
Rural ULN	500	1	8	2	20	500	30

Table 3: Results of Analysis for Manganese, Molybdenum, Nickel, Sodium, Strontium, Vanadium and Zinc in Bur Oak Foliage Collected in the Vicinity of Welland Chemical, Sarnia 1989 (µg/g dry weight).

Sampling Site	Manganese	Molybdenum	Nickel	Sodium	Strontium	Vanadium	Zinc
1	51	**1.7**	0.9	**112**	12	0.9	22
2	77	1.3	0.8	18	10	<0.5	14
4	46	1.0	0.9	49	21	<0.50	21
5	36	1.1	0.8	39	10	0.7	37
6	27	0.9	<0.6	13	2.7	<0.5	19
7	58	1.3	0.8	**79**	15	0.8	23
8	67	1.0	<0.6	29	13	<0.5	18
9	86	0.6	<0.6	44	11	<0.5	18
10	73	**2.2**	<0.6	**66**	9	0.5	27
11	23	1.1	<0.6	**280**	13	0.7	18
12	45	0.9	<0.6	**115**	15	0.6	16
Rural ULN		1.5	5	50		5	250

Figure 2: Distribution of Chloride in Bur Oak, 1989

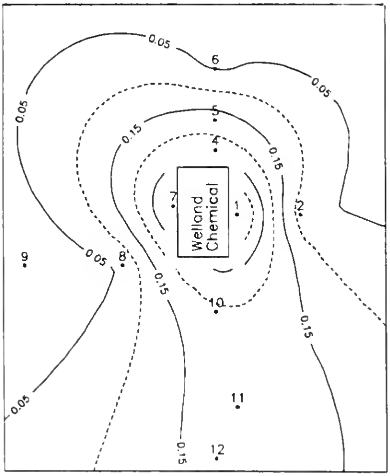


Figure 3: Distribution of Aluminum in Bur Oak, 1989

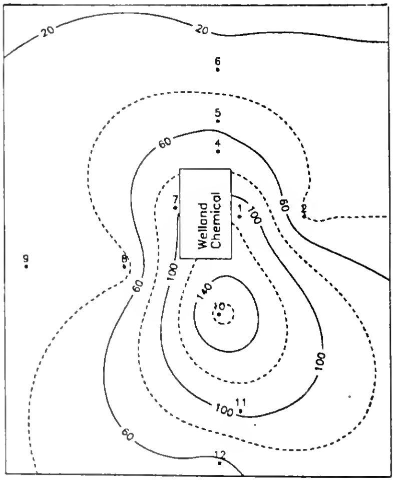


Figure 4: Distribution of Sodium in Bur Oak, 1989

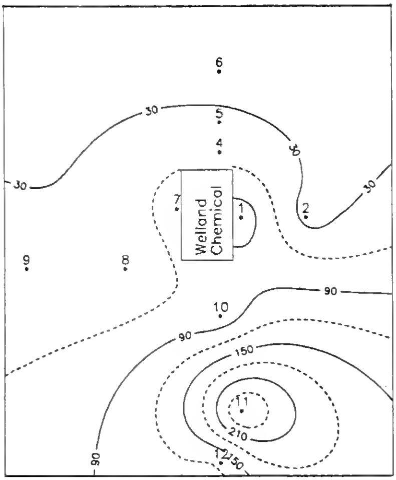
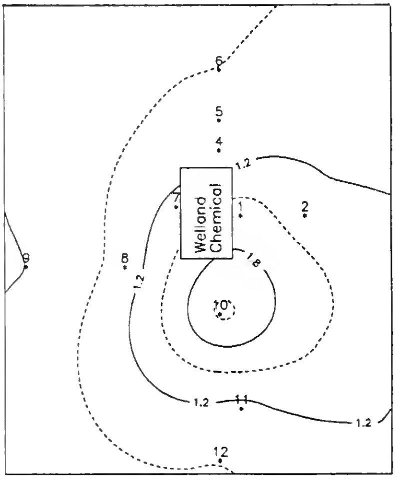


Figure 5: Distribution of Molybdenum in Bur Oak, 1989



4 Discussion

Typical chloride injury has been observed on foliage of sensitive plant species near the company in all years in which this survey has been conducted. Until 1982 extensive chloride injury was observed on foliage in an area up to 250 meters from the company. Since 1982, significantly less injury has been observed on sensitive plant species with injury being limited to Sites 1,4,7 and 10 (within 100 meters of the company's perimeter). Significant regeneration of less sensitive plant species, typically weed species, has been observed at Site 1. There was no injury at Site 10 in 1989. This was considered due in part, however, to the death of chloride sensitive bur oaks in the immediate vicinity of that site in 1986. The death of these trees also necessitated a change in the oak tree sampled for chemical analysis.

As noted in the 1986 and 1987 reports (7,8), significant declines in both leaf injury and foliar chloride concentrations were observed between the 1982 and 1983 growing seasons. With the exception of a small increase in chloride concentration at Sites 1,4,7 and 10 in 1987 there has been relatively little change in both parameters since that time. While the levels of chloride in bur oak are low with respect to pre-1983 levels, there were exceedances of the Rural Upper Limit of Normal for chloride at six sites around the company in 1989.

Aluminum levels in bur oak have followed the pattern for chloride. Levels dropped significantly after 1982, remained constant from 1983 to 1986, rose in 1987 and were back to 1983 levels in 1989. Although there was a pattern of declining aluminum concentration with distance from the company, all values in 1989 were well below the Rural Upper Limit of Normal for aluminum in tree foliage.

Sodium results for the 1989 vegetation collection were in the same range as the results from 1982 to 1987. Although uptake of sodium as sodium chloride from the roadside ditch continues to result in obvious contamination of foliage at Site 11, the amount taken up was not high enough to influence the interpretation of the chloride results at this site, vis-a-vis Welland Chemical. This uptake from the ditch can be readily seen in the distribution of sodium in bur oak foliage as shown in Figure 4.

Twelve of the other thirteen elements analysed for were well below the Rural Upper Limit of Normal for each element. For these twelve (cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, sodium, strontium, vanadium and zinc) there was no pattern of declining concentration with distance from the company. There was a weak pattern of declining concentration with distance from the company for molybdenum (see Figure 5). While the levels of molybdenum were very low (0.9 to 2.2 ppm), the Upper Limit of Normal was exceeded at sampling sites 1 and 10.

5 Appendices

5.1 Derivation and Significance of MOE "Upper Limits of Normal" Contaminant Guidelines

The MOE "upper limits of normal" contaminant guidelines essentially represent the expected maximum concentration of contaminants in surface soil (non-agricultural), foliage (tree and shrub), grass, moss bags and or snow from areas of Ontario not subject to the influence of point sources of emissions. "Urban" guidelines are based upon samples collected from centers of minimum 10,000 population. "Rural" guidelines are based upon samples collected from non-built-up areas. Samples were collected by MOE personnel using standard sampling techniques (ref: Ministry of the Environment, 1983. Field Investigation Manual. Phytotoxicology Section - Air Resources Branch: Technical Support Sections - NE and NW Regions). Chemical analyses were performed by the MOE Laboratory Services Branch.

The guidelines were calculated by taking the arithmetic mean of available analytical data and adding three standard deviations of the mean. For those distributions that are "normal", 99% of all contaminant levels in samples from "background" locations (i.e. not affected by point sources nor agricultural activities) will lie below these upper limits of normal. For those distributions that are non-normal, the calculated upper limits of normal will not actually equal the 99th percentile, but nevertheless they lie within the observed upper range of MOE results for Ontario samples.

Due to the large variability in element concentrations which may be present across Ontario, even in background data, control samples should always be collected. This is particularly important for soils, which may show large regional variations in element composition due to difference in parent material. Species of vegetation which naturally accumulate high levels of an element also may be encountered.

It is stressed that these guidelines do not represent maximum desirable or allowable levels of contaminants. Rather, they serve as levels which, if exceeded, would prompt further investigation on a case by case basis to determine the significance, if any, of the above normal concentration(s). Concentrations which exceed the guidelines are not necessarily toxic to plants, animals or man. Concentrations which are below the guidelines are not known to be toxic.

5.2 References

1. Department of Energy and Resources Management, Air Management Branch, 1970. Investigation of Vegetation Injury Complaint in the Vicinity of St. Clair Chemical Limited, Sarnia, Ontario.
2. Ontario Ministry of the Environment, 1978. Report of a Phytotoxicology Section Investigation near Welland Chemical Ltd., Scott Road, Sarnia, on August 30, 1978.
3. Ontario Ministry of the Environment, 1980. A Report of Two Phytotoxicology Section Investigations near Welland Chemical Ltd., Scott Rd., Sarnia in 1979.
4. Ontario Ministry of the Environment, 1981. A Report on the Phytotoxicology Section Investigation near Welland Chemical Ltd., Scott Road, Sarnia, 1980.
5. Ontario Ministry of the Environment, 1984. A Report on the Phytotoxicology Section Investigation near Welland Chemical Ltd., Scott Road, Sarnia, 1980 to 1984. Report No. ARB-172-84-PHYTO.
6. Ontario Ministry of the Environment, 1986. A Report on the Phytotoxicology Section Investigation near Welland Chemical Ltd., Scott Road, Sarnia, on August 20, 1985. Report No. ARB-221-86-PHYTO.
7. Ontario Ministry of the Environment, 1986. A Report on the Phytotoxicology Section Investigation near Welland Chemical Ltd., Scott Road, Sarnia, on August 20, 1986. Report No. ARB-182-86-PHYTO
8. Ontario Ministry of the Environment, 1988. A Report on the Phytotoxicology Section Investigation near Welland Chemical Ltd., Scott Road, Sarnia August 17, 1987. Report No. ARB-02-88-PHYTO. ISBN 0-7729-4198-X
9. Ontario Ministry of the Environment, 1983. Field Investigation Manual. Phytotoxicology Section - Air Resources Branch; Technical Support Sections - NE and NW Regions
10. Ontario Ministry of the Environment, 1989. Ontario Ministry of the Environment "Upper Limit of Normal" Contaminant Guidelines for Phytotoxicology Samples. Phytotoxicology Section - Air Resources Branch ARB-138-88-Phyto. ISBN: 0-7729-5143-8